CHAPTER I

INTRODUCTION

The United States maintains three types of strategic nuclear weapons: bombers, land-based missiles, and submarine-based missiles. The purpose of this triad is to deter the Soviet Union from initiating a nuclear war and, if deterrence should fail, to enable the United States to employ nuclear forces in a manner deemed appropriate by the national command authority. To ensure that the United States maintains strategic forces that fulfill these objectives, President Reagan announced in 1981 an ambitious plan for upgrading the U.S. strategic triad. Although many details of that plan have been adjusted during the last five years, major programs are under way in all three legs of the triad.

U.S. STRATEGIC FORCES

The United States currently has about 240 B-52 bombers and 56 FB-111 bombers available for strategic missions. To upgrade the bomber force, the United States is deploying air-launched cruise missiles (ALCMs) on B-52 bombers, procuring 100 B-1B bombers, and developing an advanced technology bomber (ATB). 1/ Bombers can either fly into the Soviet Union to deliver nuclear weapons or fire the long-range ALCMs from outside the Soviet Union's borders. One advantage of the bombers is that they can be launched and, in the event of a change in war plans, recalled.

Minuteman intercontinental ballistic missiles (ICBMs) are housed in concrete silos and are the only U.S. forces that currently have the speed, accuracy, and yield to reach the Soviet Union quickly and to destroy targets, such as Soviet ICBM silos, that have been hardened to withstand a nuclear attack. The United States has 450 single-warhead Minuteman II ICBMs and

1. As B-1Bs are deployed, the primary mission of B-52Gs that have not been modified to carry cruise missiles will be changed to the support of conventional forces. A total of 90 B-52Gs have been modified to carry air-launched cruise missiles (ALCMs) and B-52Hs are currently being modified. Approximately 40 B-52Hs can be modified before the SALT II limit is reached on ballistic missiles with multiple independently targetable reentry vehicles (MIRVs) and bombers with ALCMs. That limit will probably be reached in December of this year.

550 triple-warhead Minuteman III ICBMs deployed in underground silos. To upgrade the ICBM force, the United States will soon deploy 50 10-warhead MX ICBMs that will have much greater capability to destroy hardened Soviet facilities. The Administration is asking the Congress to authorize deployment of another 50 MX ICBMs and is developing plans for a small mobile ICBM.

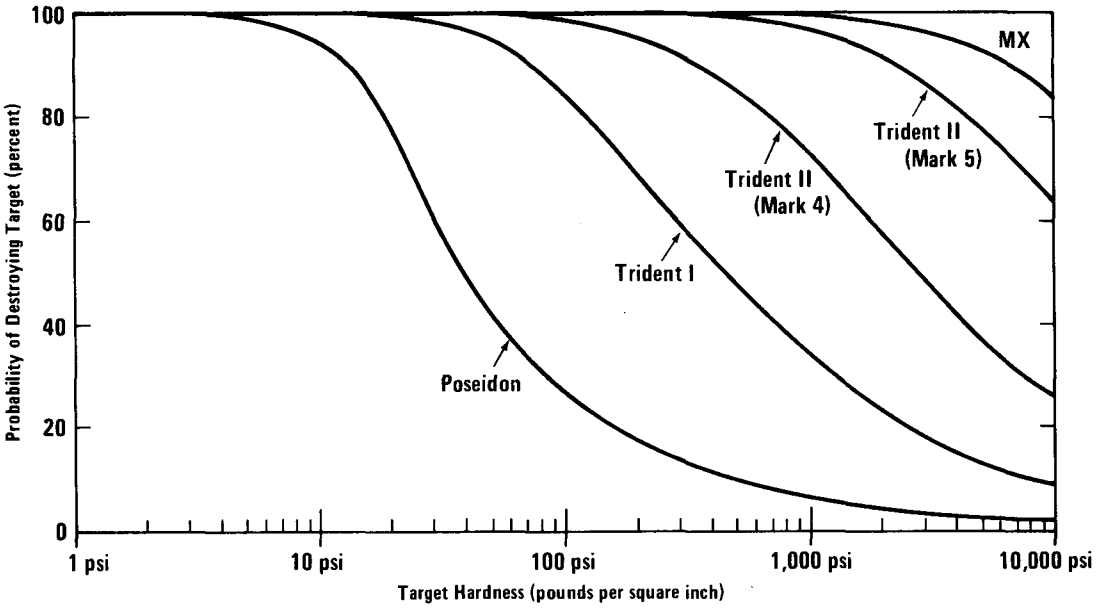
Finally, the United States has submarines that carry submarine-launched ballistic missiles (SLBMs). Submarines are a particularly important part of the triad of strategic weapons because, when at sea, they are less vulnerable to an attack by the Soviet Union than either bombers or ICBMs based in silos, thus helping to ensure that U.S. strategic weapons would survive a nuclear first strike by the Soviet Union and be able to retaliate. The United States has 28 Poseidon submarines and eight Trident submarines designed to carry SLBMs. Twelve of the 28 Poseidon submarines have been modified to carry 16 eight-warhead Trident I SLBMs. The United States will probably continue to retire the aging Poseidon submarines and build toward a force of 20 Trident submarines, each of which will carry 24 SLBMs.

DEPLOYING THE TRIDENT II MISSILE: THE ADMINISTRATION'S PLAN

The Administration plans to deploy the Trident II missile aboard the Trident submarines, thereby exploiting the ability of those submarines to carry larger and more powerful SLBMs. The seven Trident submarines currently deployed and the eighth, which began sea trials in May 1986, are designed to carry the Trident I ballistic missile. According to the Administration's plan, however, the ninth and subsequent Trident submarines would be equipped with the new Trident II ballistic missile. When the first eight Trident submarines receive an overhaul after about 10 years of service, they will be "backfitted" with the Trident II missile--that is, the Trident I missiles will be taken out and replaced with Trident II missiles.

Deploying the Trident II missile would greatly increase the capability of the sea-based leg of the U.S. strategic nuclear triad, replacing existing missiles with more powerful and accurate missiles. Whereas the Trident I carries eight Mark 4 warheads, the Trident II would be able to carry either 11 to 13 Mark 4 warheads or six to nine Mark 5 warheads, which are heavier and have a higher yield. In addition, the Trident II would be about twice as accurate as the Trident I as a result of modifications developed through the Improved Accuracy Program, an intensive study by the Navy designed to find and remedy the sources of inaccuracy in ballistic missile trajectories.

Figure 1.
Capability of Ballistic Missile Warheads Against the Target Spectrum



SOURCE: Congressional Budget Office.

NOTE: Warhead capability is measured here by Single Shot Kill Probability (SSKP)—the probability that an arriving warhead will destroy a target of given hardness. For the method used in calculating the SSKP, see Appendix A.

The greater accuracy and higher yield of the Trident II equipped with Mark 5 warheads would greatly improve the effectiveness of the missile against targets hardened to withstand a nuclear attack. Consider the ability of warheads to destroy a very hard facility such as an ICBM silo that has been strengthened so it has only a 50 percent probability of suffering major structural damage if exposed to 5,000 pounds per square inch (psi) of overpressure. 2/ If a Mark 4 warhead on a Trident I missile reaches the 5,000-psi target and detonates, the probability that it will destroy the target--known as the Single Shot Kill Probability (SSKP)--is about 15 percent. The SSKP of the Mark 4 and Mark 5 warheads on the Trident II missile against a 5,000-psi target is about 40 percent and 80 percent, respectively (see Figure 1 above). The Mark 5 warheads on the Trident II missile are, therefore, nearly as effective against most hardened targets as the warheads on the MX ICBM.

2. Overpressure is pressure exerted on a surface in excess of standard atmospheric pressure, which is 14.7 pounds per square inch. Overpressure can knock down buildings and--if the overpressure is high enough--shake, deform, or crush underground structures.

The deployment of the Trident II would rapidly increase the number of U.S. ballistic missile warheads that can destroy hardened targets. The United States currently has only 1,650 ballistic missile warheads (the Mark 12 and the Mark 12A warheads on Minuteman III ICBMs) that have a significant capability against moderately hardened targets. By the year 2000 when 20 Trident submarines would be deployed under the Administration's plan, the U.S. inventory of hard-target warheads on ballistic missiles would have grown to approximately 6,800, including 4,800 warheads on Trident II SLBMs and at least 500 warheads on MX ICBMs.

The rapid expansion in the number of hard-target warheads would improve U.S. capability to damage the Soviet command and control system and the silos that protect Soviet ICBMs--the preeminent leg of the Soviet strategic nuclear triad. Pursuit of this objective, however, has raised several questions. Would this capability increase the chance that the Soviet Union would launch its ICBMs upon warning of a U.S. attack? Would this capability encourage Soviet leaders to take measures to protect other components of their strategic forces in a manner that accentuates tensions and the potential for conflict? In sum, would this expansion in U.S. capability strengthen or weaken deterrence?

In addition to the hard-target capability of the Trident II missile, questions have been raised about the cost of the system. Between 1987 and the year 2000, the Administration's plans call for spending $26.1 billion in budget authority (in fiscal year 1987 dollars) to develop and procure Trident II missiles. Is the high cost of procuring the Trident II missile justified by its greater payload and accuracy? Might it be more efficient to rely on the successful Trident I missile until it approaches the end of its service life, rather than replacing it earlier with the Trident II?

This study analyzes these two issues--hard-target capability and cost--to provide a foundation for understanding the differences between the Trident I and Trident II missile programs. Chapter II assesses hard-target capability and reviews the arguments for and against expanding this capability. Chapter III presents the effect on cost, scheduling, and hard-target capability of the Administration's plan and of three alternatives that would deploy more Trident I missiles in place of Trident II missiles.

CHAPTER II

ASSESSING HARD-TARGET CAPABILITY

The Soviet Union, like the United States, has protected many important weapons, military command centers, and other facilities by placing them in concrete and steel structures that increase the probability they will survive a nuclear attack. The Trident II, however, would greatly expand the capability of the United States to attack and destroy such Soviet facilities. This chapter first discusses hardened facilities and develops two measures--classes of warheads and ability to destroy a fixed target set--by which to quantify the effects of deploying the Trident II missile, and then reviews the main arguments both in favor of and against hard-target capability. This material provides background for analysis of the Administration's plan and alternatives in Chapter III.

DEFINING HARDENED FACILITIES

The detonation of a nuclear weapon produces many effects including heat, electromagnetic pulse, wind, radiation, shock waves, and a crater. Although a facility can be protected from most of these effects by being located underground in a concrete, steel-reinforced structure, it is not currently possible to provide significant protection for any facility that is within the crater dug by a blast. In addition, a structure located outside the crater of a blast is exposed to the crushing force of shock waves and their secondary effects, which include the movement of components within a structure and vibration. Such secondary effects can, for example, disable an ICBM--even if the ICBM silo is structurally undamaged--by causing the ICBM to collide with the wall of the silo or by causing electrical components to fail as a result of vibration.

These destructive effects are difficult to evaluate, and significant uncertainty exists regarding the size of nuclear blast required for a particular probability of disabling a facility. Given this uncertainty, it is common to assume the worst case: a Soviet facility will survive and perform its function unless the facility suffers major structural damage. Thus, the hardness of a facility can be evaluated according to the size of blast--measured by the highest or "peak" overpressure of the blast--at which the facility has a 50 percent chance of suffering major structural damage. For example, a

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TABLE 1. SYSTEM FOR RATING THE HARDNESS OF TARGETS

Hardness Rating	Hardness (pounds per square inch)	Types of Targets
Soft	0-50	Vehicles Buildings
Medium-hard	50-1,000	Munitions bunkers Leadership bunkers Command and control centers Older Soviet ICBM silos
Hard	1,000-3,000	Minuteman ICBM silos
Very Hard	Over 3,000	Newer Soviet ICBM silos Tunnels for submarines

SOURCE: Congressional Budget Office.

facility hardened to 5,000 pounds per square inch (psi) has a 50 percent probability of suffering major structural damage from a 5,000-psi peak overpressure. 1/ This system of rating the hardness of facilities was employed in this study and is summarized in Table 1. Because of the factors mentioned above, however, extensive damage might occur to facilities exposed to levels of overpressure far lower than the level at which they are rated.

The facilities that the United States and the Soviet Union have hardened fall roughly into three groups. Soviet silos for single-warhead

1. The probability that a facility will survive a blast depends on the duration of the period of high overpressures as well as on the peak overpressure. For example, a particular silo might have a 50 percent probability of surviving a peak overpressure of 5,000 psi generated by a warhead with a large explosive power or "yield" and an associated long period of high overpressures. The same silo might also have a 50 percent probability of surviving a peak overpressure of 6,000 psi generated by a warhead with a smaller yield and an associated shorter period of high overpressures. For simplicity, therefore, the duration of the period of high overpressures is normally turned into a function of peak overpressure by establishing a reference yield. In this paper, the reference yield is one megaton (1,000 kilotons), meaning that the yield of the reference explosion is equivalent to the explosive power generated by one megaton of TNT.

ICBMs and shallow underground structures such as munitions bunkers, leadership bunkers, and command and control centers might range in hardness, based on the system described above, from 50 psi to 1,000 psi. These structures are referred to in this study as "medium-hard" targets. 2/ "Hard" structures, such as Minuteman ICBM silos, might range in hardness from 1,000 to 3,000 psi. Finally, command and control centers deep underground, tunnels for submarines, and Soviet silos for multiple-warhead ICBMs probably have a hardness greater than 3,000 psi and are referred to as "very hard" targets. 3/ Facilities hardened to less than 50 psi are "soft" targets.

MEASURING HARD-TARGET CAPABILITY

Just as the hardness of targets varies, so does the capability of warheads against those targets. The probability that a warhead will destroy a target depends both on system reliability (the probability that the missile will deliver the warhead to the target and that the warhead will detonate) and the warhead's Single Shot Kill Probability (SSKP--the probability that a warhead will destroy a target of specified hardness when it arrives and detonates). 4/ The SSKP of a warhead is a function of both the explosive power or "yield" of the warhead and its accuracy. 5/ The yield of a warhead is measured by the kilotons of TNT that would be required for an explosion of similar power. The accuracy of a warhead is measured by the Circular Error Probable (CEP), the radius of a circle drawn around a target

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2. Of the approximately 1,400 Soviet ICBMs, about 500 are older single-warhead ICBMs (the SS-11 and the SS-13) that are probably based in medium-hard silos. The SS-11 silos, for example, reportedly were hardened only to between 200 and 400 psi (see Robert Berman and John Baker, *Soviet Strategic Forces* (Washington, D.C.: Brookings Institution, 1982), p. 91). Some uncertainty exists as to whether the SS-11 silos were hardened further, but statements by the Department of Defense (DoD) suggest they have not been (see DoD, *Soviet Military Power* (1986), p. 24).

3. Silos for Soviet ICBMs with multiple independently targetable reentry vehicles (MIRVs)--the SS-17, SS-18, and SS-19--are commonly reported to be hardened to between 4,000 and 6,000 psi. See *Jane's Weapon Systems* (London: Jane's Publishing Company, 1985), p. 8; *Aviation Week and Space Technology* (October 12, 1981), p. 22.

4. In this study, all calculations of the capability of a group of ballistic missile warheads to destroy a set of targets assume a missile system reliability of 80 percent. Although some missiles are more reliable than others, this assumption is made for three reasons. First, all point estimates of missile reliability have an accompanying band of uncertainty. Second, missile tests cannot completely emulate the conditions that would prevail during wartime. Third, there is very little public information on the reliability of either U.S. or Soviet ballistic missiles.

5. The accuracy of ballistic missile warheads is affected by many factors including the ability of the missile to place the warhead on the correct trajectory and by characteristics (continued)

such that a warhead aimed at the target has a 50 percent chance of detonating within or above the circle.

The yield of a warhead affects its SSKP because a higher yield creates a higher peak overpressure at any given radius from the blast. Since the level of overpressure dissipates rapidly as the distance from the blast increases, however, high accuracy greatly increases the probability that the target will be destroyed. For example, a Mark 4 warhead on a Trident I missile has about a 15 percent SSKP against a 5,000-psi silo. 6/ That same warhead on the more accurate Trident II has about a 40 percent SSKP against a 5,000-psi silo. A Mark 5 warhead, which has four to five times the yield of the Mark 4, has about an 80 percent SSKP if carried on the accurate Trident II.

Classification of Hard-Target Warheads

Hardened targets can, as noted above, be divided into three groups that differ markedly in their ability to resist the destructive effects of shock waves. Thus, since the ability of a warhead to destroy a target varies greatly according to the target's degree of hardness, classifying warheads simply as soft- or hard-target warheads can be misleading. To account for this relationship between warhead capability and target hardness, the Congressional Budget Office (CBO) established three classes of hard-target warheads in this study, defined by the SSKP of a warhead against targets representative of the three ranges of hardness.

Under this system of classification, warheads that have a combination of accuracy and yield resulting in an SSKP of greater than 70 percent against a 5,000-psi (very hard) target are labeled Class 1 hard-target warheads. 7/ Of the U.S. ballistic missile warheads, only the forthcoming Mark

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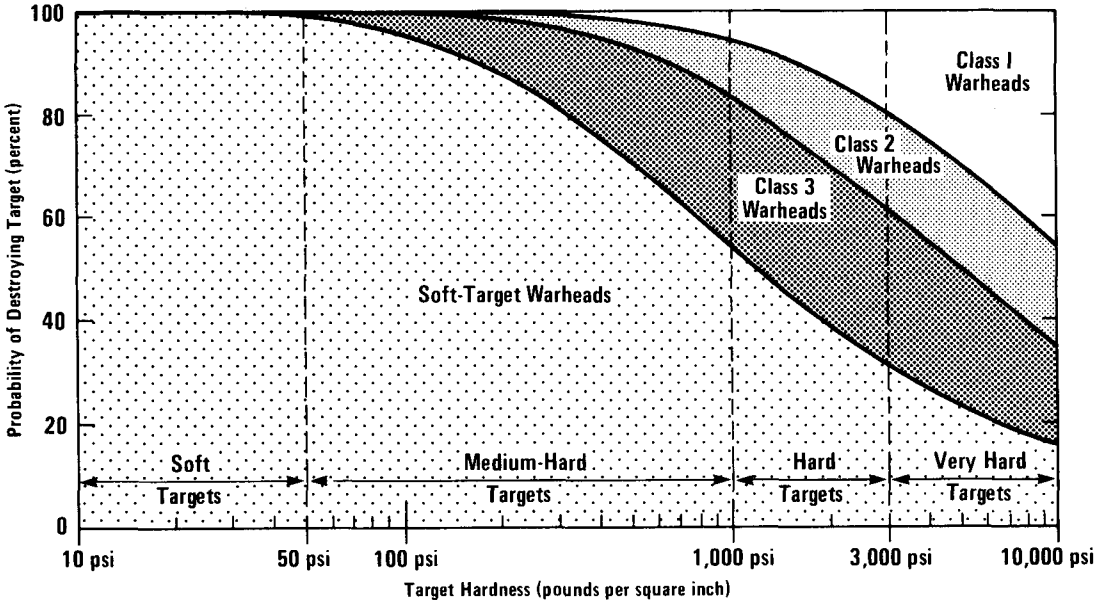
5. (continued)
of the warhead that influence its trajectory after it reenters the atmosphere. The ability of the missile to place the warhead on the correct trajectory depends in part on the distance between the missile launch and the target. In general, accuracy is better when the distance is shorter; the U.S. Navy uses a reference range when citing the CEP of a missile. For a mobile missile such as an SLBM, the ability of the missile to place the warhead on the correct trajectory also depends on the stability of the launch platform (for SLBMs, the launch platform is the submarine) and the precision with which the location of the launch platform can be established. Accuracy can also be affected by weather, the location of stars used in a stellar update guidance system, and other factors.

6. See Appendix A for the method used in making SSKP calculations.

7. An SSKP of 70 percent was chosen as the standard because two warheads with an SSKP of 70 percent would provide a high probability (greater than 90 percent) of destroying a target.

21 warhead on the MX ICBM and the Mark 5 warhead on the Trident II SLBM would meet that standard (see Table 2). None of the Soviet ballistic missile warheads currently meet that standard. Warheads that do not meet that standard but that have a 70 percent SSKP against a 2,000-psi target are Class 2 hard-target warheads. The Mark 12A warheads on the U.S. Minuteman III and warheads on the Soviet SS-18 (Mod 4) and SS-25 fall into that class (see Table 3). Class 3 hard-target warheads meet neither of the above standards but have an SSKP of 70 percent against a 500-psi target. The U.S. ballistic missile warheads in this class are the Mark 4 warheads on the Trident II missile and the Mark 12 warheads on the Minuteman III missile. Warheads on the Soviet SS-17 (Mod 3), SS-19 (Mod 3), and probably the forthcoming SS-24 also belong in that class. The capability of warheads in these classes against the full range of hardened targets is shown in Figure 2.

Figure 2.
Capability of Ballistic Missile Warheads, by Class, Against the Target Spectrum



SOURCE: Congressional Budget Office.

NOTE: Warhead capability is measured here by Single Shot Kill Probability (SSKP)—the probability that an arriving warhead will destroy a target of given hardness. Class 1 warheads have an SSKP of at least 70 percent against a 5,000-psi target. Class 2 warheads do not meet that standard but have an SSKP of at least 70 percent against a 2,000-psi target. Class 3 warheads do not meet either of those standards but have an SSKP of at least 70 percent against a 500-psi target. All other warheads are soft-target warheads.

TABLE 2. CLASSIFICATION OF CURRENT U.S. BALLISTIC MISSILE WARHEADS

Warheads	Yield (kilotons)	CEP a/ (feet)	SSKP b/ (percent)
Class 1 Hard-Target Warheads			
MX Mark 21 c/	300	300	93
Trident II Mark 5 c/	475	500	79
Class 2 Hard-Target Warheads			
Minuteman III Mark 12A	335	600	57
Class 3 Hard-Target Warheads			
Minuteman III Mark 12	170	600	39
Trident II Mark 4	100	500	37
Soft-Target Warheads			
Minuteman II	1,200	2,100	17
Titan II	9,000	4,900	13
Trident I	100	900	13
Poseidon	40	1,500	3

SOURCES: Congressional Budget Office from data in John M. Collins, *U.S.-Soviet Military Balance, 1980-1985* (Congressional Research Service, Report No. 85-89S, 1985), pp. 302-313; Thomas B. Cochran, William M. Arkin, Milton M. Hoenig, *Nuclear Weapons Databook: Volume 1--U.S. Nuclear Forces and Capabilities* (Cambridge, Mass.: Ballinger Publishing Co., 1984, for the National Resources Defense Council, Inc.), pp. 113, 118; Robert S. Norris, "Counterforce at Sea: The Trident II Missile," *Arms Control Today* (September 1985), pp. 5-10; "Trident Problem," *Aviation Week and Space Technology* (May 30, 1983), p. 41; *Department of Defense Authorization for Appropriations for Fiscal Year 1985*, Hearings before the Senate Committee on Armed Services on S. 2414, 98: 2 (1984), pt. 7, p. 3426.

a. Circular Error Probable is a measure of missile accuracy. It is equal to the radius of a circle drawn around a target such that a warhead aimed at that target has a 50 percent probability of detonating within or above the circle. To reflect uncertainty regarding the precise CEP of each system, all CEP estimates have been rounded to the nearest 100 feet.

b. Single Shot Kill Probability against a silo hardened to 5,000 psi. See Appendix A for a description of the method used in the calculation.

c. Forthcoming.

TABLE 3. CLASSIFICATION OF CURRENT SOVIET BALLISTIC MISSILE WARHEADS

Warheads	Yield (kilotons)	CEP a/ (feet)	SSKP b/ (percent)
	Class 1 Hard-Target Warheads		
None c/	n.a.	n.a.	n.a.
	Class 2 Hard-Target Warheads		
SS-25 d/	550	600	69
SS-18 (Mod 4)	500	700	54
	Class 3 Hard-Target Warheads		
SS-24 d/	100	600	27
SS-17 (Mod 3)	500	1,200	24
SS-19 (Mod 3)	550	1,300	22
	Soft-Target Warheads		
SS-N-23 d/	250	2,000	6
SS-11	1,000	3,600	6
SS-N-18	500	3,000	5
SS-N-6	1,000	4,200	4
SS-N-20	100	1,800	4
SS-N-8	800	4,900	3
SS-N-17	500	4,600	2
SS-13	600	6,100	2

SOURCES: Congressional Budget Office from data in John M. Collins, *U.S.-Soviet Military Balance, 1980-1985* (Congressional Research Service, Report No. 85-89S, 1985), pp. 302-313; Barton Wright, *Soviet Missiles: Data From 100 Unclassified Sources* (Brookline, Mass.: Institute for Defense and Disarmament Studies, 1985); International Institute for Strategic Studies, *The Military Balance, 1985-1986* (London: IISS, 1985), pp. 158-165; Michael R. Gordon, "CIA Downgrades Estimate of Soviet SS-19," *National Journal*, 29 (July 20, 1985), p. 1692; *The Salt II Treaty*, Testimony by Paul Nitze before the Senate Foreign Relations Committee, 96:1 (1979), pt. 1, pp. 439-482; "Soviets' Nuclear Arsenal Continues to Proliferate," *Aviation Week and Space Technology* (June 16, 1980), pp. 68-76; Jeffrey Sands and Robert S. Norris, "A Soviet Trident II," *Arms Control Today* (September 1985), p. 7.

NOTE: n.a. = not applicable.

a. Circular Error Probable, a measure of missile accuracy, is the radius of a circle drawn around a target such that a warhead aimed at that target has a 50 percent probability of detonating within or above the circle. To reflect uncertainty regarding the precise CEP of each system, CEP estimates have been rounded to the nearest 100 feet.

b. Single Shot Kill Probability against a silo hardened to 5,000 psi. See Appendix A for a description of the method used in the calculation.

c. According to the DoD, the Soviet Union has retired all SS-18 (Mod 1), SS-18 (Mod 3), and SS-19 (Mod 2) ICBMs. The warheads on these missiles were Class 1 warheads.

d. Estimates of the yield and CEP for the newly deployed SS-25 and the forthcoming SS-24 and SS-N-23 are speculative. If the SS-25 warhead has slightly better yield or accuracy than noted above, it would belong in Class 1. If the SS-24 warhead has a much larger yield than noted above (for example, 300 kt), it would belong in Class 2.

Other ballistic missile warheads, including those on the SS-11 ICBM, SS-13 ICBM, and all Soviet SLBMs, are soft-target warheads. U.S. warheads in this category include those on the Minuteman II ICBM, Trident I SLBM, and Poseidon SLBM.

Number of Hard-Target Warheads

The three classes of warheads can be used to evaluate the growth in the number of U.S. and Soviet strategic hard-target warheads. In this study, however, only the growth in strategic ballistic missile capability--ICBMs and SLBMs--will be measured. Weapons on strategic bombers, sea-launched cruise missiles (SLCMs), and nuclear weapons based in Western Europe (ground-launched cruise missiles (GLCMs) and Pershing II ballistic missiles) are not measured because they are designed for different missions. 8/

Whereas warheads on ICBMs and SLBMs can reach their targets in 15 to 30 minutes and therefore are referred to as "prompt" warheads, bomber-delivered ordnance--bombs, air-launched cruise missiles (ALCMs), and short-range attack missiles (SRAMs)--require several hours. 9/ Therefore, although bombs and ALCMs--and probably the next generation of SRAMs--can be highly effective against hardened targets, the time required for their delivery makes them ineffective in "time-urgent" missions such as destroying Soviet ICBMs while they are still in their silos, and destroying Soviet command and control centers before crucial decisions can be made and communicated. SLCMs, like ALCMs, fly slowly and thus are ineffective against time-urgent targets. 10/ GLCMs and Pershing II missiles, which are stationed in Western Europe, are designed to deter and respond to an attack on Western Europe rather than on the United States.

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8. Cruise missiles (SLCMs, GLCMs, and air-launched cruise missiles) are unmanned, jet-propelled, flying vehicles programmed to carry explosives to a target. They fly slowly (at less than the speed of sound) and are guided to their targets both by an inertial navigation system and by terrain contour matching.

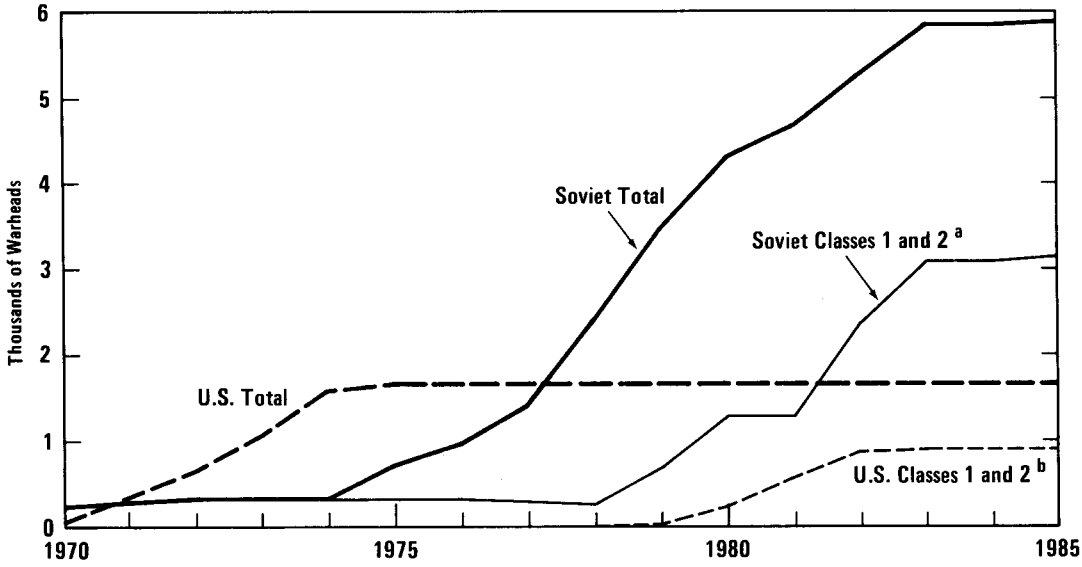
9. U.S. ALCMs are designed to carry only nuclear warheads and to be launched from strategic bombers. They can be carried either in the weapons bay or on pylons attached to the wings. The range of ALCMs is approximately 2,500 kilometers (km). SRAMs are rocket-propelled, inertially guided, air-to-surface missiles. Their speed (three to four times the speed of sound) and range (50-200 km, depending on the altitude at which they fly) enable bombers to attack air defenses or other facilities before they fly near them.

10. The nuclear land attack version of the SLCM, which has been deployed for less than three years, has the range (2,500 km), yield (200-250 kt), and accuracy to destroy hardened targets in the Soviet Union. Using SLCMs as part of a coordinated strategic attack on the Soviet Union, however, would be complicated because they are carried on ships and submarines that have conventional naval responsibilities.

Figure 3 shows the growth of U.S. and Soviet prompt strategic hard-target warheads. The United States started to deploy ICBMs with multiple independently targetable reentry vehicles (MIRVs) in the early 1970s and developed a five-to-one lead in prompt hard-target warheads by 1974. The Soviet Union, however, began to close the gap the following year by beginning to deploy the SS-17, SS-18, and SS-19. The Soviet Union had a large lead in prompt hard-target capability by 1980 and expanded that lead through 1983.

Since 1983, the number of prompt hard-target weapons possessed by both nations has been stable, with the Soviet Union maintaining its lead. The Soviet Union now has about 2,800 Class 3 prompt hard-target warheads compared with 750 for the United States. Similarly, the Soviet Union has approximately 3,200 Class 2 prompt hard-target warheads; the United States

Figure 3.
Number of U.S. and Soviet Ballistic Missile Hard-Target Warheads, Fiscal Years 1970-1985



SOURCE: Congressional Budget Office.

NOTE: The U.S. and Soviet totals count all three classes of hard-target warheads deployed on ballistic missiles. Class 1 warheads have a Single Shot Kill Probability (SSKP) of at least 70 percent against a 5,000-psi target. Class 2 warheads do not meet that standard but have an SSKP of at least 70 percent against a 2,000-psi target. Class 3 warheads do not meet either of those standards but have an SSKP of at least 70 percent against a 500-psi target.

[a] The Soviet Union deployed a few Class 1 warheads—the SS-18 (Mod 2) and SS-19 (Mod 2)—between 1975 and 1980. Otherwise, all warheads in this subtotal are Class 2 warheads.

[b] The United States has not deployed any Class 1 warheads to date.

has 900. As noted above, neither nation currently has any Class 1 prompt hard-target warheads. 11/

Capability Against a Target Set

The number of prompt hard-target warheads possessed by the United States, however, only partially reflects the potential effectiveness of those warheads. Other crucial factors are the number of hardened facilities in the Soviet Union, the strategic objective (for example, to attack all strategic targets or only a limited set of targets), and the ability of U.S. warheads to survive an initial strike by the Soviet Union.

The Soviet Union has roughly 2,000 hardened strategic facilities including 1,300 to 1,400 ICBM silos and 600 to 700 other facilities such as command and control centers, warhead bunkers, and submarine tunnels. 12/ The United States must consider which of these facilities must be targeted and which, among those targeted, must be attacked promptly. As noted above, potential time-urgent targets include Soviet ICBM silos and command and control centers.

In addition to determining which targets are time-urgent, the United States must determine which missions are appropriate for prompt hard-target weapons. There are three basic perspectives on the appropriate mission. One view is that the United States should be able to attack promptly and destroy a large percentage of the entire set of hardened targets in the Soviet Union (see the following section for a discussion of these perspectives). To attack promptly all hardened strategic targets in the Soviet Union, the United States would need enough hard-target ballistic missile warheads to be able to attack roughly 2,000 targets. The capability of all U.S. ballistic missiles against such a target set is depicted in Figure 4.

In a situation where the United States is considering this mission following a major attack on U.S. forces, however, a high percentage of U.S.

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11. The United States currently has over 2,000 Class 1 warheads (bombs and ALCMs) based on strategic bombers and will have more as the Air Force deploys ALCMs on additional B-52H bombers and deploys B-1B bombers.

12. As of April 1985, the Soviet Union had about 1,400 ICBM silos. The Soviet Union has replaced more than 70 silo-based SS-11 ICBMs with mobile SS-25 ICBMs during the past year, however, and has begun to dismantle the silos for the SS-11s. The Department of Defense expects the Soviet Union to continue to retire SS-11 ICBMs, probably deactivating all of them by the mid-1990s. Consequently, by the mid-1990s the number of Soviet ICBM silos could decrease to less than 900. (See Department of Defense, *Soviet Military Power* (1986), p. 26.) In addition to hardened strategic targets, the Soviet Union reportedly has 700 hardened leadership bunkers (Jeffrey Richelson, "PD-59, NSDD-13, and the Reagan Strategic Modernization Program," *Journal of Strategic Studies*, vol. 6 (June 1983)).

silo-based ICBMs would probably have been destroyed. The United States then would have to depend primarily on the retaliatory capability of SLBMs (and, if procured, mobile ICBMs) to perform missions against time-urgent targets. 13/ This capability is depicted in Figure 5.

A second perspective is that the United States needs only the ability to conduct a limited retaliatory strike against hardened time-urgent targets in order to strengthen deterrence of a Soviet strike against targets in the United States. In this context, "limited" refers to an attack against a few targets or a subset of targets such as ICBM silos. The number of Soviet facilities targeted in a limited retaliatory attack by the United States might range from just a few to more than 1,000. Figure 6 provides an example of the performance of U.S. SLBMs in this less demanding mission by depicting their capability against a target set of 500 hardened facilities.

The third perspective is that there is no need for the United States to be able to conduct prompt attacks on hardened targets in the Soviet Union and that a strong capability to destroy hardened Soviet targets might increase the likelihood that a crisis would escalate into nuclear war. In this perspective, continued growth in the number of U.S. prompt hard-target warheads could weaken rather than strengthen U.S. security.

In addition to illustrating different perspectives on the mission of U.S. prompt hard-target capability, Figures 4 through 6 show that capability against target sets hardened to two different levels: to 5,000 psi (very hard) and to 2,000 psi (hard). The depiction of U.S. capability against targets hardened to 5,000 psi illustrates how U.S. forces would perform both if the Soviet Union were to harden all of its strategic facilities to the range at which its silos for MIRVed ICBMs are currently hardened (4,000 to 6,000 psi), and if these facilities were to survive and perform their function until suffering major structural damage. Depicting U.S. capability against facilities hardened to 2,000 psi illustrates the view that--because of effects such as vibration and the movement of internal components--Soviet facilities

13. In reality, some silo-based ICBMs might survive a Soviet attack and some SLBMs would probably be destroyed. For example, on the basis of the SS-18's yield and accuracy presented in Table 3 and an assumed reliability for the SS-18 of 80 percent, about 16 percent of the U.S. Minuteman ICBM missiles would survive an attack by 2,000 SS-18 (Mod 4) warheads without major structural damage (it is assumed that the U.S. silos are hardened to 2,000 psi). The Department of Defense is more optimistic, estimating that 20 percent to 35 percent of the silos would survive (see DoD, *Soviet Military Power* (1986), p. 25). In addition, missile-carrying submarines in drydock or at dockside during an attack would probably be destroyed. During a crisis, however, the United States would seek to maximize the survival of submarines by sending all seaworthy vessels on patrol.

Figure 4.

Performance of U.S. ICBMs and SLBMs Against a Large Target Set, Fiscal Years 1970-1985

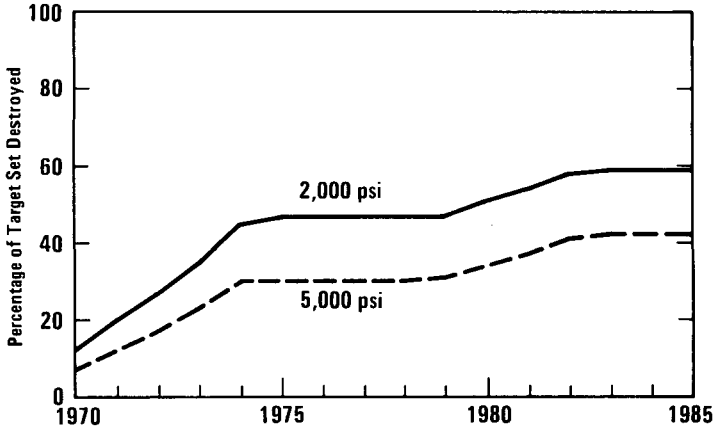


Figure 5.

Performance of U.S. SLBMs Against a Large Target Set, Fiscal Years 1970-1985

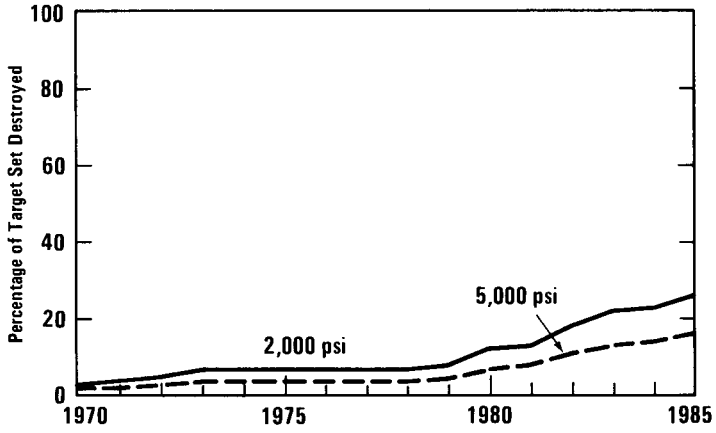
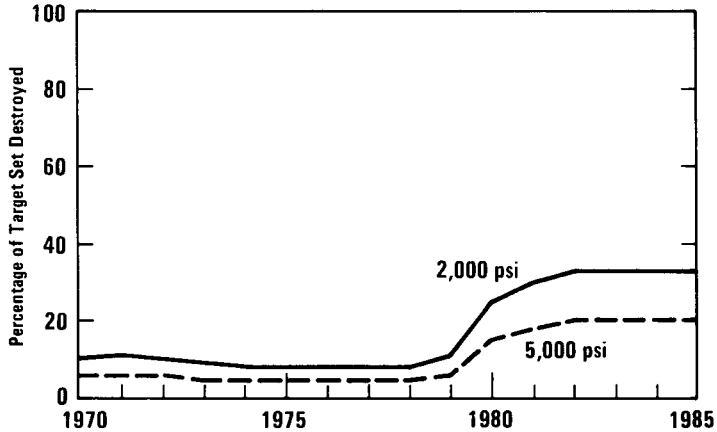


Figure 6.

Performance of U.S. SLBMs Against a Small Target Set, Fiscal Years 1970-1985



SOURCE: Congressional Budget Office.

NOTES: A large target set (Figures 4 and 5) is 2,000 facilities; a small target set (Figure 6) is 500 facilities. All three figures illustrate the performance of ballistic missiles against target sets hardened to 2,000 psi and 5,000 psi. The calculations are based on the assumptions that no more than two warheads are allocated against any one target and that the reliability of SLBMs is 80 percent. U.S. warheads are allocated to maximize the percentage of targets destroyed.

might fail long before suffering major structural damage. This view is probably more representative of the way the Soviets would view the survival of their own forces.

PERSPECTIVES ON HARD-TARGET CAPABILITY

The measures developed above--number of hard-target warheads and the capability of warheads against a hardened target set--show substantial growth in hard-target capability under the Administration's plans to deploy the Trident II. Perspectives on the necessity of that growth, however, differ greatly. Proponents and opponents put forward divergent views on such fundamental issues as deterrence, fighting a nuclear war, and crisis stability. This study lays out the main arguments on both sides of the issue but makes no attempt to determine whether additional hard-target capability is needed.

Arguments in Favor of Increasing U.S. Prompt Hard-Target Capability

The Soviet Union has a considerable lead in the deployment of prompt hard-target warheads. At the end of 1985, the Soviet Union had about three and one-half times as many as the United States. This imbalance has drawn attention to the issue of hard-target capability and, more specifically, to the vulnerability of U.S. facilities to a Soviet attack. Increasing U.S. hard-target capability would not decrease the vulnerability of those facilities directly, but, according to proponents, it would decrease their vulnerability indirectly by enhancing U.S. deterrence of an initial Soviet strike.

The argument that an increase in U.S. prompt hard-target capability would enhance deterrence has two parts: deterrence of a "massive" Soviet strike and deterrence of a "limited" Soviet strike. Presidential Directive 59 (PD-59), signed by President Carter and reportedly endorsed by the Reagan Administration in National Security Decision Directive 13 (NSDD-13), 14/ postulates that the deterrence of a massive Soviet strike--that is, a Soviet attack against all of the major military and economic facilities in the

14. Each U.S. Administration has a system of documents for implementing national security policy decisions made by the President. Under different Administrations, however, these documents are given different titles. President Nixon used National Security Decision Memorandums (NSDMs), President Carter used Presidential Directives (PDs), and President Reagan uses National Security Decision Directives (NSDDs). Although the content of NSDD-13 has been widely reported, the Reagan Administration has not confirmed either the content of the document or its existence.

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United States--is maximized if the United States can threaten a retaliatory strike against the targets that Soviet leaders value most. 15/ Thus, on the assumption that the Soviet leaders value most highly the domestic political control structure and military power of the state, the United States has deemphasized the targeting of economic targets (industrial sites and transportation systems) and has emphasized the targeting of Soviet leadership, command and control centers, strategic weapon facilities, and major military facilities supporting conventional forces. Providing full coverage of these Soviet assets might require the deployment of several thousand survivable hard-target warheads.

An increase in the number of U.S. prompt hard-target warheads might also enhance deterrence of a limited Soviet first strike, which might range from an attack on a few targets in the United States to an attack on an entire subset of targets such as U.S. ICBM silos. In arguing for expanded hard-target capability, proponents cite two reasons why the current U.S. capability to respond to a limited Soviet strike with either a limited or a massive attack on soft targets in the Soviet Union might not deter Soviet leaders from conducting such a strike. First, the Soviet Union might not expect the United States to retaliate (for example, the United States might choose not to retaliate against soft urban-industrial targets in the Soviet Union in fear of a counterattack against similar targets in the United States). Second, the Soviet Union might be willing to accept the potential loss of some urban-industrial centers or other soft facilities.

This rationale was reflected in National Security Decision Memorandum 242 (NSDM-242), signed by President Nixon in January 1974, which called for the development of plans for limited retaliatory strikes on diverse sets of Soviet targets. In calling for such plans, NSDM-242 had two objectives. One was to enhance deterrence by increasing the risks faced by Soviet leaders in conducting a limited attack against U.S. facilities. For example, U.S. possession of prompt hard-target warheads (as opposed to hard-target warheads with long delivery times such as ALCMs and bombs), would increase the possibility that the United States might retaliate by striking Soviet ICBM silos with the goal of destroying ICBMs before they could be launched. The second objective was that, should deterrence fail, limited options would increase the flexibility accorded U.S. leaders in determining which type of attack would serve the goal of controlling escalation while resolving the conflict on acceptable terms.

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15. A massive strike would probably include an attack on all major command and control bunkers, military bases, leadership centers, strategic weapons, harbors, and industrial centers. Because of the collocation of many of these facilities with urban areas, all major cities would probably be destroyed regardless of whether they were targeted directly.